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STRAWBERRY DISEASES

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STRAWBERRY DISEASES

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Strawberries are attacked by many diseases, which vary widely in their destructiveness and distribution. The ideal way to cope with these diseases is to hold them in check through preventive measures.

In most localities losses may be reduced by (1) using adapted cultural practices, (2) selecting adapted varieties, and (3) planting disease-free stock.

Cultural practices.—Use the cultural practices that are adapted to your locality. These will enable you to grow vigorous plants. Two cultural practices recommended in most localities are crop rotation and frequent renewal of plantings and plant stocks.

Varieties.—Select varieties that do well in your locality. If a particular disease is a problem, choose, if possible, varieties resistant to it.

Disease-free stock.—Use disease-free stock for planting new fields. Only a few of the major diseases are now common throughout the country. But most of them can be introduced into new areas by planting infected stock.

When you buy planting stock it is best to patronize nurseries that sell plants certified to be disease free by the State plant-inspection service.

If you use runner plants from old fields to set new fields, do not use any from plants that you know or suspect are diseased.

DISEASES OF THE ENTIRE PLANT

Diseases of the entire plant include all the virus diseases of strawberries and leaf variegation (also called spring yellows).

Virus Diseases

Viruses are disease-causing agents so small they cannot be seen, even through a microscope. Several viruses infect strawberries. Most strawberry virus diseases are a combination of two or more of these viruses (a virus complex).

Though one virus or even certain combinations of viruses may not cause the plant to show obvious symptoms or noticeable loss of vigor, their presence in the plant does weaken it. Loss of vigor may show up in the weakened plant if growing conditions are unfavorable. Obvious symp-

toms may appear if the plant is infected with an additional virus.

A strawberry plant can never be rid of a virus infection (except under some specialized experimental techniques), and the infection passes on through runners to all daughter plants. Most of the viruses are spread from plant to plant by aphids.[1]

Virus diseases that can be recognized by clear-cut symptoms include crinkle, yellows, multiplier, leaf roll, and aster yellows; these are described under "Symptoms."

Other virus diseases that ordinarily produce no identifying symptoms are unnamed. The viruses causing these diseases can be identified only through a process called indexing. Indexing consists of grafting the plant to be tested to an indicator plant. If the plant being tested is virus infected, the indicator plant shows clear-cut symptoms.

Distribution.—Virus diseases that do not produce obvious symptoms are widespread in the Eastern United States and occur in every strawberry-producing section of the country. Crinkle and yellows are prevalent in the Pacific States. Of the other virus diseases, which are less common, multiplier is found principally in the North Central States, leaf roll in the Northeastern States, and aster yellows throughout the United States.

Symptoms.—Symptoms of the recognizable virus diseases are listed below.

Crinkle.—Plants are a lighter shade of green than normal. Leaves tend to lie flat on the ground. Leafstalks are short. Some leaves are distorted or wrinkled; usually these leaves have many pinpoint-size, yellow spots scattered over the surface.

Yellows.—Plants are dwarfed

[1] Mainly *Pentatrichopus* spp.

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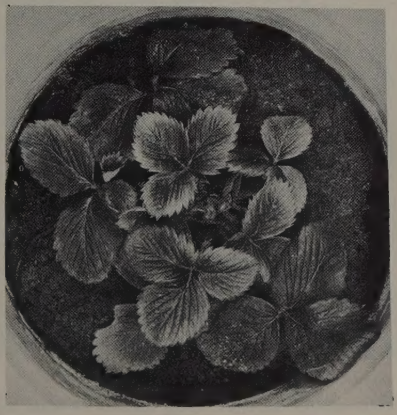
Crinkle symptoms in a Marshall strawberry plant.



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Yellows symptoms in a Marshall strawberry plant.

and have very few runners. Leaves usually cup upwards; they have dull green centers and yellow edges.

Multiplier.—Plants are spindly and have many crowns, sometimes as many as a hundred. Leafstalks are thin and somewhat shorter than normal. Leaves are from one-third to one-half normal size. There are only a few very short runners or none.

Leaf roll.—Leaves tend to cup downward and often are rolled or twisted into a tube.

Aster yellows.—Early symptoms are yellowing, dwarfing, and cupping of young leaves. Later, most plants showing early symptoms die suddenly, as do all attached runner plants. Sometimes abnormal green, leafy flowers are produced before the plant dies. When the disease appears in a field, usually only a few scattered plants are affected. Sometimes, however, over half the plants in a field may be affected; the rate of spread varies greatly from year to year.

Damage.—All virus diseases weaken plants, cut runner formation, and hold down berry yields.

Crinkle and yellows do the most damage. Crinkle often reduces yields by 50 percent or more. Yellows reduces both quantity and quality of yield and shortens the life of the planting. Losses from both diseases are greatest in strawberries of the Marshall variety, which is very sensitive to both diseases. Shasta, Lassen, and Northwest varieties are rather tolerant to both diseases.

Virus diseases that do not produce obvious symptoms may reduce yields as much as 50 percent, judging by tests conducted on experimental planting stock. Strawberries of all varieties appear to be weakened by these diseases,

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Virus-infected and virus-free Blakemore plants grown under the same experimental conditions. Infected plants at left have no obvious symptoms other than poor vigor. Poor vigor may also result from a number of unfavorable growing conditions.

but some are more sensitive than others.

What to do if disease occurs.—If only a few plants in a field show symptoms of crinkle or yellows, remove them at once, and apply insecticides to control aphids (p. 5). This is especially helpful in fields less than 1 year old. If these diseases appear in many plants, ask your county agent for help in determining where the infection is coming from and whether removing infected plants will be practical.

If multiplier or leaf roll appears in the field, it may help to take out diseased plants when you cultivate.

Plants with aster yellows may be left in place; usually they die, and healthy plants grow over them.

Prevention.—To prevent damage from virus diseases, plant only virus-free stock[2] and grow it under conditions that will prevent or reduce the movement of insect virus carriers into the planting. Locate new plantings as far as possible from existing strawberry fields; plow under old fields immediately after harvest; and apply insecticides to control the winged aphids that are present in the early spring and the fall. Virus-free stock has proved to be more vigorous and productive than common (or virus-infected) stock, even in localities that have no apparent virus-disease problem.

Virus-free plants are available from nurseries the country over. Plants grown under a State-supervised certification program and labeled "essentially virus free" or "substantially virus free" are preferable to those labeled merely "grown from virus-free plants." To obtain certification of their stock nurserymen are required to use special planting stock and to follow specified isolation or control practices, or both.

Virus-free plants of about 40 varieties are available. These include Blakemore, Catskill, Florida Ninety, Marshall, Midway, Pocahontas, Robinson, Shasta, Sparkle, Surecrop, and Tennessee Beauty.

Virus-free strawberries can become infected after they are planted if virus-infected plants are near and strawberry aphids are present.

In areas where virus diseases have been a problem, insecticides should be carefully applied in the early spring and fall to prevent a buildup of winged aphids on new beds. Apply demeton or parathion after young plants are well established and repeat the application in 3 weeks if any aphids are present. In the early spring make another application before the plants begin to bloom. If aphids persist after the fruit is set, use tepp, diazinon, or malathion. After harvest, or about the first of September, apply demeton or parathion again.

[2] In this publication "virus-free stock" refers to plants that are substantially free from recognized viruses. There is no way to determine whether a plant is free from all viruses.

PRECAUTIONS

Insecticides are poisonous to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Keep insecticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them.

When handling an insecticide, wear clean, dry clothing.

Avoid repeated or prolonged contact of insecticides with your skin.

Wear protective clothing and equipment if specified on the container label. Avoid prolonged inhalation of insecticide dusts or mists.

Avoid spilling insecticide concentrate on your skin, and keep it out of your eyes, nose, and mouth. If you spill any on your skin, wash it off immediately with soap and water. If you spill it on your clothing, launder the clothing before wearing it again.

After handling an insecticide, do not eat, drink, or smoke until you have washed your hands and face. Wash your hands and face and any other exposed skin immediately after applying insecticide. If you become ill while working with an insecticide, get medical attention immediately.

To protect water resources, fish, and wildlife, do not contaminate lakes, streams, or ponds with insecticide. Do not clean spraying equipment or dump excess spray material near such water.

To protect honey bees and other pollinating insects that are necessary in the production of many crops, apply insecticide, when possible, during hours when the insects are not visiting the plants.

Avoid drift of insecticide to nearby bee yards, crops, or livestock.

Dispose of empty insecticide containers at a sanitary land-fill dump, or bury them at least 18 inches deep in a level, isolated place where they will not contaminate water supplies. Wrap small containers in heavy layers of newspapers and place them in the trash can.

Demeton, parathion, and tepp are extremely dangerous. They should be applied only by a person thoroughly familiar with their hazards who will assume full responsibility for safe use and comply with all the precautions on the labels.

Do not apply demeton within 21 days before a harvest, parathion within 14 days, diazinon within 5 days, or malathion or tepp within 3 days.

Parathion, tepp, diazinon, and malathion dusts are available ready for use from insecticide dealers. Use 1-percent tepp or parathion dust or 4-percent malathion or diazinon dust at the rate of 15 to 30 pounds per acre, the choice of rate depending upon the size of the plants.

Ingredients for sprays are available in a concentrated form, either as an emulsifiable concentrate or a wettable powder, that should be diluted with water. For a low-gallonage spray (10 gallons or less per acre) use only an emulsifiable concentrate; a wettable powder may clog the nozzles of the sprayer. Use enough of the concentrate to make 0.4 pound of demeton, parathion, or tepp per acre or 1 pound of diazinon or malathion.

Leaf Variegation (Spring Yellows)

Leaf variegation is a noninfectious disease caused by a defect in the hereditary makeup of the plant. It has been found in at least 40 varieties of strawberries. Among these are Blakemore, Dixieland, Howard 17 (Premier), Vermilion, and most everbearing varieties.

Distribution.—Leaf variegation can be found in any section of the United States. It is not common in most modern varieties.

Symptoms and damage.—The green of new leaves becomes pale and faintly spotted or streaked with yellow. The intensity of the spotting or streaking differs with variety and season. Symptoms may appear in the spring, disappear during warm weather, and reappear in the fall or the next spring. Sometimes the symptoms become progressively worse each spring until plants are stunted and weak and leaves are almost white.

Badly affected plants are unproductive and die prematurely. Affected plants never recover; all their runner plants show variegation in some degree.

Prevention.—There is no known cure for leaf variegation. It can be prevented, however, by use of non-variegated planting stocks. Certain strains or stocks of Blakemore and Howard 17 that are comparatively free of this disease are available. Varieties currently sold as "substantially virus free" (p. 5), except for some stocks of Vermilion and most stocks of Dixieland, have so far (1965) been free of leaf variegation. In the development of virus-free strawberries, only the strains of a variety that do not show variegation have been selected for distribution.

ROOT DISEASES

Red stele, verticillium wilt, black root-rot, and nematode infection are the major root diseases. Red stele and verticillium wilt are caused by fungi. The cause of black root-rot is not

known. The most common damage by nematodes is caused by two types that enter the roots to feed.

Red Stele

Red stele,[3] the most serious fungus disease of strawberries in the United States, attacks plants during the late winter and spring. The fungus that causes the disease attacks no other crop except loganberries. The fungus does not persist in soils in the South or in well-drained soils in any area; it persists in all other soils.

Red stele is spread from one area to another principally by distribution of diseased plants. It is spread within an area by water that moves within or over the soil and by soil carried on farm implements.

Distribution.—Red stele is common throughout the northern two-thirds of the country. It has also been found as far south as Georgia and Arkansas.

Symptoms and damage.—The symptom that positively identifies this disease is found in the center (or stele) of the root. In a normal root both the center and the part surrounding the center are yellowish white. In a plant with red stele the center is a distinctive brownish red, which contrasts with the normal yellowish white of the part around it. The red color may extend the length of the root or it may show only a short distance above the dead tip. It does not extend to the crown of the plant; any discoloration there has some other cause.

The red center is best seen during the spring, up to the time of fruiting. Later in the season it may disappear as the rotted roots are replaced with new ones.

Other symptoms that should make you suspect red stele are: Poor growth and frequent wilting of plants, especially those in low, wet areas of the field; younger leaves that have a bluish-green cast; older leaves that turn yellow or red. When dug, some of the roots of diseased plants have a rattail appearance—unbranched with black tips or black patches.

Plants infected with red stele are stunted. They wilt in dry weather. Often they die just before the fruit starts to ripen. In diseased plants that do not die symptoms disappear during warm summer weather. These plants may recover and produce a few worthless fruits, but symptoms usually recur in the late fall or the following spring.

Red stele may infect only a few plants in low areas of the field. Or it may be distributed throughout a field or strawberry-growing region. It is most destructive in heavy or poorly drained soils that are saturated with water in cool weather when the fungus is active; the swimming spores move through this free water to attack the plants.

What to do if the disease occurs.—At present there are no chemical or cultural treatments that will assure a normal crop in an infected planting. The only

[3] Caused by *Phytophthora fragariae* Hickman.

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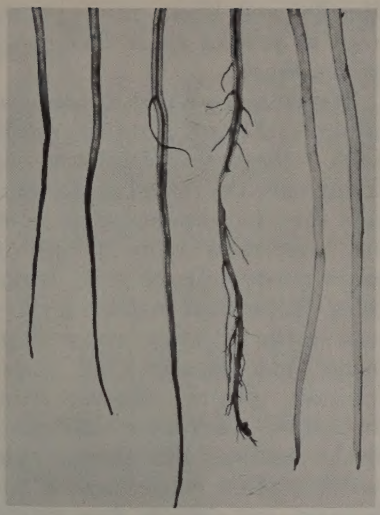
Plant at right infected with red stele. Compare with normal plant, left. Note that infected plant lacks small feeding roots.



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Roots at left and center infected with red stele; roots at right normal. Note dead tips on roots at left. Roots in center are split lengthwise to show reddened core. Roots at right are split to show normal white center.

practical control for red stele in fields infested with the fungus is to replant with red stele-resistant varieties. There is no practical treatment or crop rotation that will rid the soil of the fungus, and the fungus can persist for years once the soil becomes infested.

Resistant varieties grown on infested soil should be rotated with other crops. If a resistant variety is grown continuously on infested soil there is a good chance that a new, more virulent race of the fungus—to which the variety is not resistant—will appear. The chance that this will happen is reduced, but not removed, by crop rotation.

Resistant varieties introduced so far (1965) are Columbia, Fairland, Guardsman (Canada), Hood, Midway, Molalla, Puget Beauty, Redcrop, Redglow, Siletz, Sparkle, Stelemaster, Sunrise, Surecrop, Temple, and Vermilion. Some of these that are adapted to conditions in particular areas of the country are of poor quality when grown elsewhere. Others (Sparkle, Surecrop, and Fairland, for example) are widely adapted. Some are such recent introductions that their values are not yet known.

New races of red stele fungus that can damage some of the resistant varieties have recently appeared in several areas. Stelemaster, Sunrise, and Surecrop carry resistance to the races that are known in the East. Hood,

Molalla, and Siletz carry resistance to several races that occur in the West.

Prevention.—Avoid, if possible, setting infected planting stock. Look roots over carefully to see if any have the rattail appearance that may indicate red stele. Cut any suspicious roots to see if there are typical red stele symptoms. State plant-inspection services cannot identify every shipment that contains red stele-infected plants because the distinctive red center that positively identifies this disease may not be present at the time of inspection, or only a few plants from a nursery field may be diseased.

Avoid planting any but resistant varieties in infested land.

Verticillium Wilt

The fungus [4] that causes this disease lives from year to year in the soil. Besides strawberries, many other common crops and several kinds of weeds are also hosts of this fungus.

Distribution.—Verticillium wilt occurs throughout the United States.

Symptoms and damage.—The fungus is most active during cool weather. In new plantings symptoms appear about the time runners begin to form. In established plantings symptoms appear about the time fruit begins to ripen.

Outer leaves wilt and dry at the margins and between the veins; they become dark brown. Few, if any, new leaves develop. New roots that grow from the crown often are very short and have blackened tips. Plants appear to be dry and flattened. Black sunburn lesions may appear on leafstalks and runners. Severely affected plants collapse, sometimes abruptly. Less severely affected plants are unproductive. In the East less severely affected plants usually recover and produce normally the next year. In the West affected plants usually do not recover.

The disease will often appear in mother plants but not in rooted daughter plants. Thus it is more obvious when strawberries are grown in hills than when they are grown in matted rows.

Some of the most susceptible varieties are Dixieland, Earlidawn, Jerseybelle, Klondike, Lassen, Northwest, Shasta, and Vesper. Varieties that have some resistance are Blakemore, Catskill, Marshall, Robinson, Siletz, Sunrise, Surecrop, and Vermilion.

Prevention.—In the East allow 2 years between tomatoes, or peppers, or potatoes and strawberries.

In the West do not grow susceptible strawberry varieties on land that has a history of having been planted to tomatoes, peppers, potatoes, cotton, okra, melons, eggplant, mint, apricot, almond, pecan, cherry, avocado, roses, or cane fruit. The verticillium wilt fungus has been known to persist in the soil in the Pacific States for more than 10 years.

[4] *Verticillium alboatrum* R. and B.

In areas where verticillium wilt is a major problem, consider a variety that has some resisistance to this disease.

Fumigation of the soil with chloropicrin, frequently with methyl bromide added for weed control, has given good results, but the cost ranges from $200 to $600 per acre.

Black Root-Rot

Black root-rot is the general name for several root troubles that produce similar symptoms.

The cause of black root-rot is not known, but one or more of the following may be partly responsible: Soil fungi, nematodes, winter injury, fertilizer burn, drought, and too much salt, water, or alkali in the soil.

Distribution.—Some form of black root-rot has been found in every strawberry-growing area. The injured plants may be scattered through the planting or grouped in one or more parts of it.

Symptoms and damage.—To be able to recognize the symptoms of black root-rot at various stages of the root's development it is necessary to know what a normal root looks like at each stage.

Newly developed main roots of a normal strawberry plant are pliable and almost white. After several months they generally become woody and are dark brown to black on the surface. When this dark surface is scraped away a yellowish-white living core can be seen. Small feeder roots that branch out from the main roots are white as long as they are active.

Roots of a plant with black root-rot have one or more of the following symptoms:

Root system much smaller than in normal plants.
Main root spotted with patches or zones that are darker than the rest of the root.
Feeder roots lacking, or feeder roots spotted with dark patches or dark zones.
All or part (usually the tip) of main roots killed. A cross section of a dead root shows it backened throughout.

Plants with black root-rot are less vigorous than normal plants and produce fewer runner plants. Those with severe root-rot may die.

Control.—Use only healthy white-rooted plants. No other general recommendation for reducing losses from black root-rot or for preventing it can be given. Your county agent or State agricultural college may be able to suggest measures for controlling it that have been successful in your area.

Nematode Infection

Nematodes are worms too small to be seen easily by the unaided eye. Many species live in the soil. Several of these attack strawberry roots; several others attack the plant aboveground (see pp. 20–22).

Two species that attack strawberry roots—namely, the northern root-knot nematode and the meadow nematode—enter the roots to feed. The sting nematode and several others feed only on the surface of the roots.

Nematodes that enter the roots to feed can stay alive in the roots when plants are dug, stored, and shipped—even if they are shipped barerooted. Nematodes that feed on the surface of the roots usually are dislodged when the plants are dug and the soil removed from the roots.

Most root nematodes are more destructive in sandy soils than in clay soils.

Northern root-knot nematode

The northern root-knot nematode [5] is the only species of root-knot nematodes that attacks strawberry plants. It also attacks many other plants and common weeds; it does not attack most grains and grasses.

Distribution.—Much cropland in the northern two-thirds of the country is infested with the northern root-knot nematode. It is found in the South only where it has been introduced on strawberry plants or where peanuts have been grown extensively.

Symptoms and damage.—These nematodes form swellings (or galls) on the roots. Swellings range in size from minute to about ¼ inch in diameter, averaging ⅛ inch in diameter. Usually there are several short branch roots just above the swelling.

A severe infection has the same effect on the plant as removing most of the roots: Plants are weakened, are more subject to drought injury, and make fewer runner plants; therefore they produce less fruit. Damage usually becomes more severe as the nematode population on the plant increases during the second and later fruiting years.

What to do if plantings are infected.—Practice very shallow cultivation to keep roots from further damage. Eliminate weeds. Maintain high soil fertility. Irrigate during dry periods.

Prevention.—Plant only stocks that are free of root knot. This is important because infested strawberry plants may carry nematodes into land where they do not now occur.

Many nurseries now treat their plants to free them of root knot. Several State quarantine services

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Roots infected with the northern root-knot nematode. Note swellings, and branch roots above each swelling.

[5] *Meloidogyne hapla* Chitwood.

intercept plants that have root galls. Some of these services do not allow root-knot infected plants to be shipped into the State or into specified areas. Others allow the plants to be shipped in, but warn the buyer that the plants are infected.

If strawberries must be planted in soil that is heavily infested with root-knot nematodes it may be profitable to fumigate the plot or field (see p. 14).

Whether a field is fumigated or not, a high organic level in the soil appears to reduce nematode damage.

Root-lesion nematode

Several species of root-lesion nematodes [6] attack strawberries. One or more of these can also attack most other cultivated crops, most trees and ornamentals, and many weeds. This is one of the nematode groups that may be a cause of black root-rot (see p. 11).

Distribution.—Root-lesion nematodes that attack strawberries infest most cropland in the United Sates.

Symptoms and damage.—If infection is severe, young roots may become wiry and brown. Plants may be stunted and less vigorous, less productive, and more easily damaged by drought than uninfected plants. If infection is not severe, damage usually is not serious.

Severe infections occur only when the root-lesion nematode population in the soil is high.

What to do if plantings are infected.—Keep root damage to a minimum by very shallow cultivation; eliminate weeds; maintain high soil fertility; and irrigate during dry periods.

Prevention.—Plant stock that is substantially free of root-lesion nematodes. Clean white roots indicate that few or no root-lesion nematodes are present.

If strawberries must be planted in soil that is heavily infested, soil fumigation is recommended (see p. 14).

Sting nematode

The sting nematode [7] has been injurious to strawberries only in Florida and other Southeastern States. It also attacks several other crops.

Symptoms and damage.—Outer surface of the roots has dark spots or is entirely brown. Small roots are killed.

If infection is severe, the plant becomes stunted and weak; leaf margins turn brown. Some plants die. Often only a part of a planting is noticeably affected.

What to do if plantings are infected.—If many plants are severely infected, plow up the planting. The yield will not warrant the time and effort needed to cultivate and harvest the crop.

Prevention.—Plant stock that is substantially free of sting nematodes. Plants from a field in-

[6] *Pratylenchus* spp.

[7] *Belonolaimus* spp.

SOIL FUMIGATION

Before Planting

Nematocides will, if applied to the soil properly, kill a high percentage of most nematodes that attack strawberries. Most fumigants must be applied at least 3 weeks before planting time. Because the toxic gas they give off will kill plants as well as nematodes, this gas must be out of the soil before the strawberries are set.

Usually a grower will prefer to use a soil fumigant first on only a part of the land to see if increased yields justify the expense. If other conditions are favorable, yields will increase markedly the first year. Although the few nematodes that remain after fumigation can increase in number rapidly, the beneficial effect of fumigation may last throughout the life of the strawberry planting.

Before applying soil fumigants to a field, consult your county agent or State agricultural experiment station for suggestions concerning materials to use. If you wish a copy of Agriculture Handbook 286, "Chemical Control of Plant-Parasitic Nematodes," send a post card request to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250.

In general, successful fumigation before planting consists of careful preparation of the soil and application of a correct amount of fumigant to the proper soil depth with special equipment. The fumigant should be applied only when soil temperature measured at a depth of 6 inches is between 50° and 80° F. Soil should be neither waterlogged nor dry at the time of application. Plants should not be set sooner than recommendations of the manufacturer as stated on the label.

In Established Plantings

The material dibromo chloropropane has been used with good results to reduce root knot and sting nematodes on established strawberry plantings. It is applied as a side dressing at rates recommended by the manufacturer.

Precautions

Soil fumigants are poisonous. Handle them in accordance with the manufacturer's directions on the package. Do not breathe the fumes.

Never risk getting the liquid into the eyes or mouth. Do not allow the liquid to stay on the skin; wash it off promptly with soap and water. If liquid is spilled on shoes, gloves, or other clothing remove the clothing without delay, and do not wear again until thoroughly aired or cleaned.

fested with these nematodes will carry them if soil remains on the roots. To remove this nematode from infected plants, wash soil off the roots with water.

If strawberries must be planted in soil that is infested with the string nematode, row or broadcast application of a soil fumigant is recommended (see p. 14).

FOLIAGE, BUD, AND FLOWER DISEASES

The most serious diseases that attack the aboveground parts of the plant are four fungus leaf diseases, bud rot (also caused by a fungus), and nematode infection.

Three of the leaf diseases—leaf spot, leaf scorch, and leaf blight—cause little or no damage in dry or irrigated areas. The fourth, powdery mildew, is seldom a problem except in some cool, irrigated areas or when very susceptible varieties are grown.

Leaf Spot, Leaf Scorch

Leaf spot [8] and leaf scorch [9] do about the same kind of damage and are spread in the same way. Methods of control are the same for both. Often both diseases occur on the same plant; they are sometimes mistaken for different stages of the same disease.

Each disease is caused by one particular fungus. Neither fungus is known to attack any other field or garden crop. Each usually is brought into a field when new plants are set or may be carried in from nearby fields by birds or insects, by farm implements, or on the hands and clothing of workmen.

Both fungi live through the winter on infected plants. Cool weather and an abundance of moisture favor their spread.

Both fungi attack leaves, leafstalks, fruitstalks, runners, and caps. The leaf spot fungus will infect these parts only when they are immature. The leaf scorch fungus will infect leaves at all stages of development.

The leaf spot fungus also causes black-seed of berries (see p. 25). The leaf scorch fungus occasionally attacks berries but causes little damage. It is not noticeable except when it shows on green berries; then it appears as a red or brown discoloration or flecking of the surface.

Distribution.—Epidemics of leaf spot and epidemics of leaf scorch occur each year in some sections of the Gulf Coast region. In other regions, scattered epidemics occur from time to time.

Symptoms.—Early symptoms of the two diseases are similar. Differences appear as the diseases progress.

In *leaf spot,* round purple spots ⅛ to ¼ inch across can be seen on the upper side of the leaves. At first the whole spot is purple. Later, the center of the spot be-

[8] Caused by *Mycosphaerella fragariae* (Tul.) Lindau.

[9] Caused by *Diplocarpon earliana* (Ell. and Ev.) Wolf.

comes tan or gray, then almost white; the border remains purple. On the underside of the leaves the spots show as indistinct tan or bluish areas.

If other parts of the plant are attacked they are marked by spots like those on the upper side of the leaves.

In *leaf scorch,* small dark-purple spots up to one-fourth of an inch in diameter appear on the upper side of the leaves. These spots never have light centers as do those of leaf spot and they have a more irregular outline. If spots become so numerous that they cover most of the leaf, the leaf dries up and looks scorched.

Similar spots may appear on other affected parts of the plants.

Leaf spot damage.—A severe attack of leaf spot kills so many leaves that the whole plant is weakened or killed.

Whether a trace of leaf spot in a field is likely to cause much damage if left uncontrolled depends on the variety being grown and on weather conditions at the time new leaves are developing.

Several strains of the leaf spot fungus are known, which affect varieties differently. In general, the manner in which varieties react is as follows:

Fairland, Florida Ninety, Klondike, Marshall, Sparkle, Sunrise, and Vesper varieties are very susceptible to leaf spot. Dixieland, Dunlap, Fairpeake, Jerseybelle, Midway, Pocahontas, and Vermilion are moderately susceptible. Blakemore, Catskill, Earlidawn, Robinson, and Surecrop are only slightly susceptible. Albritton, Dorsett, Earlibelle, Fairfax, Howard 17 (Premier), Klonmore, Midland, Rockhill are resistant.

If there are frequent rains during early spring, a few leaf-spotted plants can start an epidemic. Clusters of spores emerge from the white centers of the spots. Rain scatters them to nearby leaves; there they germinate and start new spots. A spring application of nitrogenous fertilizer can increase the amount of the disease because it increases the amount of young leaves at the time when leaf spot is most likely to occur.

Leaf scorch damage.—A severe leaf scorch attack may kill so many leaves that the whole plant is weakened or killed. Leaf scorch also often does considerable damage to caps, leafstalks, runners, and fruitstalks as well as to the leaves. Scorch spots may girdle the fruitstalks, causing the death of flowers and young fruit.

Whether leaf scorch is likely to cause much damage in a field if left uncontrolled when found on only a few plants depends on the variety and on weather conditions during early spring and fall. In hot dry summer months there is little spread of leaf scorch.

Varieties that are susceptible to leaf scorch are Dixieland, Florida Ninety, Jerseybelle, Klondike, Midway, Pocahontas, and Vesper. Moderately susceptible varieties include Sparkle, and Tennessee Beauty. Resistant varieties are

68701

Leaf spot infection as it appears on upper side of leaves. Spots are purple with white centers.

68702

Leaf scorch as it appears on upper side of leaves. Spots are dark purple.

Albritton, Blakemore, Catskill, Earlibelle, Fairfax, Howard 17 (Premier), Robinson, Rockhill, Sunrise, and Surecrop.

What to do if disease occurs.—The fungicide sprays discussed under "Prevention," below, can be used to control both diseases.

Prevention.—Frequent renewal of strawberry fields helps prevent epidemics of leaf spot and leaf scorch. A new field in which disease-free plants are set will remain reasonably free of these diseases for the 1 to 3 years it is usually cropped.

The use of resistant varieties, if they are adapted to the growing conditions in your area, may also help.

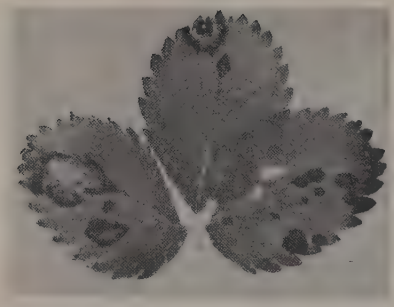
In areas where the fungi of the two diseases are present in quantity a spray program may be profitable. Spray a new bed at monthly intervals during the spring and fall of the first year with bordeaux mixture, basic copper sulfate, or such organic materials as thiram, zineb, dyrene, or captan. In the spring before fruiting, 1 or 2 sprayings are generally sufficient. Observe limitations on use of these fungicides given on page 27.

Leaf Blight

Leaf blight is generally less troublesome than leaf spot or leaf scorch. It may be a problem in cooler strawberry-growing areas. The fungus [10] that causes it lives Ev.) H. W. And.
through the winter on infected plants and is spread in the same ways as leaf spot.

Symptoms and damage.—Red to brown spots may be seen on the leaves. Spots have a purplish border, are from ¼ inch to more

[10] *Dendrophoma obscurans* (Ell. and



68700

Leaf blight as it appears on upper side of leaves. Spots are red to brown, with a purplish border.

than 1 inch across, and are oval or triangular in shape.

Leaf blight is found most often on older plants after harvest. It seldom damages these plants seriously unless they are less vigorous than normal. It seldom damages young runner plants.

Among varieties most susceptible to this disease are Catskill, Dunlap, and Robinson. Earlidawn, Empire, and Howard 17 (Premier) seem to have some resistance.

What to do if disease occurs.—The fungicide sprays recommended for prevention of leaf spot and leaf scorch can be used to control leaf blight.

Prevention.—Leaf blight can be reduced by a single application of phenyl mercury acetate spray in the spring. Spray after mulch has been removed but before there is any extensive new growth; this spray will injure actively growing foliage. A fall application before mulch is put on will reduce leaf blight, but it is usually not so effective as a spring application. Apply at the rate recommended by the manufacturer. Observe limitations on use of this fungicide given on page 27.

This spray will also control stem end rot of fruit (p. 25).

Powdery Mildew

Powdery mildew [11] occasionally becomes severe in the Pacific Northwest. It causes damage in other parts of the United States only when there are extended periods of cool weather during the growing season.

Among varieties most susceptible to this disease are Armore, Earlibelle, Jerseybelle, Lassen, Midland, Northwest, Redglow, Shasta, Stelemaster, and Tennessee Beauty. Some of the most resistant are Catskill, Dunlap, Empire, Klondike, Siletz, Sparkle, and Sunrise.

Symptoms.—The most conspicuous symptom of mildew is an upward rolling of the edges of the leaves. Also, a thin white growth of cobweblike mold appears on the lower surface of the leaves and on stems and fruit. If attack is severe, leaves may show purple blotches or they may be killed.

What to do if disease occurs.—Sulfur dust or Karathane can be used to control powdery mildew. Both of these materials, however, can severely injure leaves and flowerstalks if the weather turns hot. Both sulfur and Karathane may be applied up to the time of

[11] Caused by *Sphaerotheca macularis* (Wallr. ex Fries) W. B. Cooke.

BN–7247

Powdery mildew has caused leaves of these plants to roll up.

full bloom and again, if necessary, after harvest.

If disease is severe, avoid overhead irrigation.

Prevention.—In localities where mildew is a problem, avoid planting strawberries in places that are shaded or have poor air drainage. No spray or dust program is generally recommended.

Bud Rot

Bud rot is caused by a fungus [12] that attacks leafbuds and flowerbuds. It is easily mistaken for spring dwarf (p. 20); both diseases have similar symptoms and appear at the same time of year.

There is no known way to prevent bud rot. It is less likely to occur, however, if plants are set at the correct depth and if the soil is not piled up around plants during cultivation.

Distribution.—Bud rot occurs throughout the United States. Apparently the fungus that causes it is common in field soils. The disease is most likely to develop during cool, wet spring weather. Sometimes, plants stored at improper temperatures or those weakened in other ways in storage or shipment show a high percentage of bud rot when planted.

Symptoms and damage.—The most noticeable symptoms appear during the blossoming period. The fungus slows the development of crown buds, or kills them. The outer leaves assume a horizontal position and become darker green than normal. A few new leafbuds soon develop under what

[12] *Rhizoctonia* sp.

DN–1588

Bud rot. Plant at left infected, plant at right normal. Both plants are the same age.

is left of the original buds; these may also be killed, or they may survive as weak, spindly growths. Some plants are killed; usually, however, infected plants recover but produce no fruit that year.

Bud rot can be distinguished from spring dwarf in two ways. Plants infected with bud rot are not grouped together in a field; those with spring dwarf are. Bud rot-infected plants show rotting of leafstalks and dead or decaying bud tissues in the crown; decayed tissues are less likely to occur in plants with spring dwarf.

Nematode Infection

Three species of nematodes attack strawberry plants aboveground. One causes spring dwarf, one causes summer dwarf, and one damages leafstalks, fruitstalks, and new leaves.

Spring dwarf, summer dwarf

Spring dwarf [13] and summer dwarf [14] are caused by closely related nematode species that live inside leafbuds. The nematodes feed by sucking the sap from the tightly folded leaves within the bud. The injury to the leaves results in dwarfing and other malformations that show after the leaves unfold.

Both diseases are most commonly spread through setting of infected plants. The spring dwarf nematode does not persist in the soil long enough to spread the disease from an old planting to a new planting. The summer dwarf nematode persists long enough to spread the disease from an old

[13] Caused by *Aphelenchoides fragariae* (Ritzema-Bos) Christie.

[14] Caused by *A. besseyi* Christie.

planting to a new planting made within a year.

The diseases may also be spread within a field or area by drainage of surface water if diseased plants are at higher levels in a field.

Neither disease is now found to any great extent in most strawberry-growing areas because of successful control efforts by nurserymen and growers. Either disease can, however, if not guarded against, gain a foothold in a field and quickly spread to cause great losses.

Distribution.—In the past, *spring dwarf* has caused serious losses in several areas in the Northeastern States. Although it is now a rarity, it is found from time to time in stocks in the Atlantic States from New England to Georgia, in Texas, Michigan, and in the Pacific States. The nematodes causing spring dwarf can live through winters with subzero temperatures and through relatively hot summers. They become inactive in extremely hot summers and may die out during long, hot growing seasons.

Summer dwarf has caused damage from Virginia and Arkansas southward and in southern California. However, there is only an occasional field that has enough infected plants to reduce the yield. The nematode that causes this disease can live through mild winters as far north as southern Illinois and Delaware.

Symptoms and damage.—Symptoms of *spring dwarf* show best during the early part of the growing season, when the greatest damage is done. Leaves that develop from infected buds are narrow, twisted, and glossy. There are few or no blossom buds; therefore infected plants produce little or no fruit. Some plants are killed during the spring, but most infected plants survive. When hot summer weather brings a decrease in the number of spring dwarf nematodes the infected plants seem to recover; they produce normal-appearing runners. Most of these runners are infected and will show symptoms the following spring.

Plants infected with *summer dwarf* show symptoms on leaves that develop during the summer and early fall. The summer dwarf nematodes are present in buds in the spring, but do not build up to destructive populations until warm weather.

Affected leaves are narrow, twisted, glossy, stiffer and greener than normal, and have shorter than normal stalks. Some leaves are very small. The malformed leaves are in the center of the plant, surrounded by normal or nearly normal leaves that were formed earlier. Leaves that develop in cooler fall weather may be almost normal in both size and shape. Infected plants form fewer flowerbuds than normal. Fruit is sometimes misshapen. Most runner plants are infected.

What to do if dwarf occurs.—Take out and destroy diseased plants. Prevent drainage water from carrying nematodes to uninfected plants in the fields.

Prevention.—Plant only stock that is free of dwarf nematodes. If you obtain plants from your own field or from a neighbor, avoid those from fields that you know or suspect are infected.

Most nurseries, because of careful selection of stock, are free from these and other foliar nematodes. In most States, plants with any foliar nematodes cannot be certified by plant inspectors.

Bulb and stem nematode

The bulb and stem nematode,[15] a serious pest of clovers, sometimes attacks strawberries. It has appeared most frequently in the Pacific Northwest—usually in fields in which the pest has attacked previous crops or near infected plantings of clover.

Symptoms are short, abnormally thickened leafstalks and fruitstalks, and distorted leaves. Plants may be severely stunted and unproductive. Symptoms usually appear only on parts of the plant that develop early in the season. The disease is most severe during a cool, wet spring.

If only a few plants in a field are infected, remove and destroy them.

To prevent infection with this nematode, do not plant strawberries near or in soils that have a history of this nematode on other crops. Do not use plants from diseased fields in new plantings.

[15] *Ditylenchus dipsaci* Kuhn.

DN–1589

Spring dwarf. Plant at left infected, plant at right normal. Both plants are the same age.

Fruit Rots

Six fruit rots—gray mold rot, tan rot, hard rot, leather rot, black-seed, and stem end rot—are found in the field.

Each is caused by a different species of fungus. Gray mold rot causes the most damage, black-seed the least. Most of the fruit rots are especially troublesome in the South.

Long periods of rain and cloudy weather accompanied by temperatures favorable to one or more of the rot fungi usually precede epidemics of fruit rot.

Preventive measures are the same for all the fruit rots except stem end rot.

Gray mold rot

Gray mold rot [16] occurs throughout the United States. It is found on berries at all stages of their development.

Symptoms and damage.—Gray mold infection often starts on blossoms and green fruit—where there are frost or other injuries to the flowerstalks or caps, or where dead petals adhere to the developing fruit. Sometimes it affects flowerstalks enough to prevent development of the fruit.

Infection also may start in the part of a berry that touches the ground, another decayed berry, or a dead leaf. At first it shows as a light brown, rather soft spot. The rot spreads throughout the berry. As the berry dries out it becomes firm and tough, is a uniform brown color throughout, and is covered by a distinctive gray powder or a dusty-appearing growth.

What to do if disease occurs.—Some fruit may be saved by fungicide sprays (discussed under "Prevention") once the rot is noticed.

Prevention.—Proper spacing of plants and correct timing of fertilizer application are the most important preventive measures.

If plants in matted rows are not densely spaced or if the rows are kept narrow, the developing fruit can dry more rapidly and thus be less subject to rot than if the plants are allowed to become crowded.

BN-6984

Gray mold on unripe berry.

[16] Caused by *Botrytis cinerea* Fr.

Apply any fertilizer in fall or summer rather than in spring. Fertilizer applied in the spring produces thick foliage; shading by thick foliage prevents rapid drying of berries after rains and heavy dews; this helps form suitable conditions for development of rots.

Mulching (with straw, pine needles, or other materials) when practical, will also help reduce the damage from fruit rot; the fungi that cause fruit rots live in or on the soil and in infected leaves and plant debris. Whether plants are mulched or not, cultivate as little as possible from bloom until after harvest.

Another control measure—spraying or dusting with fungicides—probably will reduce the amount of rot damage except when conditions are extremely favorable to the growth of rot fungi. This control measure often costs more than it is worth, however.

Spray with captan, ferbam, zineb, or dyrene as soon as blossom buds are visible in the spring. Spray every 2 weeks until the berries are one-third grown. After this time, spray only if rot is present or if extensive cool or rainy periods are predicted. Observe limitations on use of these fungicides given on page 27.

Tan rot

Tan rot [17] occurs in the Southern States. It attacks both green and ripe berries.

Symptoms and damage.—Tan rot forms slightly sunken, tan-colored areas on the berry surface; these usually develop on the sides of the berries. As the rot extends into the berry, the rotted part widens and forms a cone. This can easily be removed in one piece with the point of a knife or pencil.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Hard rot

Hard rot [18] occurs throughout the United States. It has been most serious in central Florida. It attacks only ripe berries.

Symptoms and damage.—Hard rot usually attacks only berries that touch the ground as they grow. Affected berries generally are one sided and show a hard brown area on the side that touched the ground. There is a distinct line between the rot and the rest of the berry. The rest of the berry remains unchanged in appearance and in taste.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Leather rot

Leather rot [19] occurs in Alabama, Louisiana, Mississippi, Ar-

[17] Caused by *Pezizella lythri* (Desm.) Shear and Dodge.

[18] Caused by *Rhizoctonia* sp.

[19] Caused by *Phytophthora cactorum* (Leb. and Cohn) Schroet.

kansas, Missouri, Tennessee, Kentucky, Illinois, Maryland, and Virginia. It attacks both green and ripe berries.

Symptoms and damage.—On green berries, diseased areas are either dark brown or natural green outlined by a brown edging. On partly colored berries, diseased areas are light brown at the center and shade into purple at the edges. On fully ripe berries there may be no change in color or a slight darkening of the diseased area.

The healthy flesh of a berry that is even slightly rotted has a bitter taste.

If a diseased berry is cut across, there is no clear line separating diseased and healthy flesh. However, there is a marked darkening of the water-conducting system leading to each seed. In the later stages of decay the fruit becomes tough and leathery.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Black-seed

Black-seed [20] occurs most often in the South Atlantic States. It occurs less frequently in other areas where leaf spot is severe. It appears only on ripe berries.

Symptoms and damage.—Black-seed forms black spots about one-fourth of an inch in diameter surrounding groups of seeds on the surface of the berries. The berry pulp is discolored a short distance below the black surface, but there is no general decay of an infected berry. Usually only 1 or 2 spots occur on one berry, but occasionally there are as many as 8 or 10.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Spray a new bed at monthly intervals during the fall of the first year with bordeaux mixture, basic copper sulfate, or such organic materials as zineb and captan. Observe limitations on use of these fungicides given on page 27. Other preventive measures are the same as for gray mold rot.

Stem end rot

Stem end rot is sometimes destructive in Michigan and other cooler strawberry-growing areas. It attacks green or ripening fruit, and is especially severe on berries of the Robinson variety.

This rot is caused by a fungus [21] that is similar to the fungus that causes leaf blight.

Symptoms and damage.—Stem end rot usually attacks the cap first, then moves into the pulp. The cap becomes dry and brown; the pulp soft, brown, and watery. There is a distinct line between diseased and healthy tissue.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for leaf blight, page 17.

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[20] Caused by *Mycosphaerella fragariae* (Tul.) Lindau.

[21] *Gnomonia fructicola* (Arnaud) Fall.

Brown Caps

When caps are killed and dried out they turn an unattractive brown. Although this cap discoloration does not affect the taste of the berry, berries with brown caps bring a lower price than those with bright green caps.

The most common causes of brown caps are the fungi that cause the various fruit rots.

A combination of high temperature and low humidity, especially when accompanied by wind, can kill berry caps. Strawberries of Klondike, Missionary, and Blakemore varieties have weak caps that are easily killed by such weather conditions.

Prevention.—Spraying or dusting with the fungicides recommended for the prevention of gray mold rot will often reduce the amount of brown caps.

ACCEPTABLE RESIDUE TOLERANCES FOR FUNGICIDES

For certain pesticide uses the Food and Drug Administration of the U.S. Department of Health, Education, and Welfare has established acceptable residue tolerances—that is, the maximum amount of a certain pesticide that may be left in or on a certain food in its raw or natural state.

You can be reasonably sure that the residue levels of the fungicides recommended in this publication will not exceed the tolerances set for them on strawberries if you use the fungicide according to the manufacturer's directions. Read the label carefully; use no more of the fungicide than is recommended; follow exactly the directions for timing of applications; observe any other restrictions listed.

Precautions.—Some chemicals used as fungicides may be injurious to man or animals. Observe carefully the manufacturer's recommendations for safe handling, given on the container.

The table below shows the maximum dosage of fungicides that may be used on strawberries (as of 1965) and the various restrictions on application. Dosages lower than the maximum (as given on the label) usually are sufficient to control the diseases for which the fungicides are recommended.

Fungicide	Used to control—	Maximum dosage [1]	Restrictions on application
		Per acre	
Bordeaux mixture.	Leaf fungi....	2.6 pounds.....	None when used in accordance with accepted agricultural practices.
Captan.....	Fruit rots, leaf fungi.	3.8 pounds.....	Can be used anytime.
Chloropicrin....	Verticillium wilt.	1,021 pounds (75 gallons).	Wait 1 to 2 weeks before planting. Disk or aerate soil between time of application and planting.
Copper sulfate (basic).	Leaf fungi....	4 pounds.....	Same as for bordeaux mixture.
Dichlone.....	Fruit rots, leaf fungi.	0.4 pounds.....	Do not use within 3 days of harvest.
Dyrene.....	Fruit rots, leaf fungi.	3 pounds.....	Do not use within 5 days of harvest.
Ferbam.....	Fruit rots, leaf fungi.	3 pounds.....	Do not use within 14 days of harvest.
Karathane.....	Mildew.....	6 ounces.....	Do not use within 21 days of harvest.
Phenyl mercury acetate.	Leaf blight, stem end rot.	1¼ pints of 10 percent solution in 250 gallons of water.	Use in fall 10 days before bedding or in spring when plants are dormant or when they have only 1 or 2 leaves unfolding, no later.
Sulfur.....	Mildew.....	50 pounds.....	Same as for bordeaux mixture.
Thiram.....	Fruit rots, leaf fungi.	3.3 pounds.....	If applied within 3 days of harvest, remove residue by washing.
Zineb.....	Fruit rots, leaf fungi.	2.5 pounds.....	Do not use within 7 days of harvest.

[1] Given as amounts of 100 percent of the active ingredient.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

INDEX TO DISEASES

	Page
Aster yellows virus	4
Black root-rot	11
Black-seed	25
Brown caps	26
Bud rot	19
Bulb and stem nematode	22
Crinkle virus	3
Fruit rots	23–26
Gray mold rot	23
Hard rot	24
Leaf blight	17
Leaf roll virus	4
Leaf scorch	15
Leaf spot	15
Leaf variegation (spring yellows)	7
Leather rot	24
Multiplier virus	4
Nematode infection	11–15, 20–22
Northern root-knot nematode	12
Powdery mildew	18
Red stele	8
Root-lesion nematode	13
Spring dwarf	20
Spring yellows. (See Leaf variegation.)	
Stem end rot	25
Sting nematode	13
Summer dwarf	20
Tan rot	24
Verticillium wilt	10
Virus diseases	2–7
Yellows virus	3

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